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LISTS OF SPECIES

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Birds of the Parque Ecológico Lagoa da Fazenda, Sobral, Ceará state, northeastern Brazil

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Abstract: Natural areas within cities are important as they contribute to maintain biodiversity and the functioning of ecosystems. In Ceará state, inventories of birds in human-impacted areas are still scarce. Here, we inventory bird species and estimate the species richness at Parque Ecológico Lagoa da Fazenda, an urban park in the municipality of Sobral, in northeastern Brazil. We found 82 bird species, of which 16 breed in the area, three are endemics, and three others are introduced. Despite the moderate species richness detected, richness estimators revealed that sampling was sufficient to detect most species. To maintain or even increase local species richness, we suggest the cessation of urban expansion within the park, sewage dumping, and filling of the wetland, as well as further planting of native vegetation.

Key words: anthropic avifauna; Brazilian semiarid ecosystems; breeding areas; bird diversity; Caatinga; inventory; species richness

INTRODUCTION

Among the main threats to the bird diversity in Brazil are overhunting, introduced species, pollution and, remarkably, habitats loss and fragmentation (Marini & Garcia 2005), which are especially important in densely populated areas around cities. Along with decreases in biodiversity due to urban expansion, several ecosystem services can also be affected, such as pollination and diseases control, which ultimately decreases quality of life for humans (Lobada & De Angelis 2005). An alternative scenario is the maintenance of natural areas within urban matrices in order to harbor biodiversity and provide several direct benefits, such as water drainage, control of air and noise pollution, and recreational areas (Matsumoto et al. 2012). These benefits are even more remarkable when wetlands are associated to urban natural areas in arid regions as such aquatic ecosystems present high primary productivity and often high vegetation heterogeneity (Keddy 2000) and therefore increase bird diversity, for instance (Branco 2007).

In South America, one of the most arid biogeographic provinces is the Caatinga, which covers 844,453 km^2 in northeastern Brazil (IBGE 2004). In this region, annual rainfall is typically lowand seasonal, with evapotranspiration rates usually overcoming precipitation and, hence, promoting water deficit. Vegetation is xerophytic, with short, spiny, and leafless trees or treelets dominant (Caatinga *strictu sensu*), although scarce forest patches can be found in some humid areas of hills (Prado 2003). Caatinga also presents endemic fauna adapted to the scarcity of water. Among the birds, 510 species are present if all phytophysiognomies are considered (Silva et al. 2003), and of these species, 348 can be found within Caatinga *strictu sensu* (Pacheco 2004); 23 of them are restricted or nearly exclusive to Caatinga (Olmos et al. 2005).

Despite of the high bird diversity in the Caatinga and their role to the functioning of the ecosystem by acting, for example, on pollination, seed dispersal, and pest control, at least 20 species are under risk of extinction (MMA 2002). The fact that only less than 2% of Caatinga is under integral protection worsens this scenario (Maciel 2010). In this sense, providing species inventories is an important step towards a better understanding of the regional distributions of species, and these data may be valuable to drive conservation efforts. Even though the state of Ceará has been explored by ornithologists for many years (see Pacheco 2004), systematic bird inventories are still scarce and focused mainly on highland areas (Nascimento 2000; Nascimento et al. 2000; Farias et al. 2005; Nascimento et al. 2005; Albano and Girão 2008) and arboreal Caatinga (i.e., *'Caatinga arbórea e*

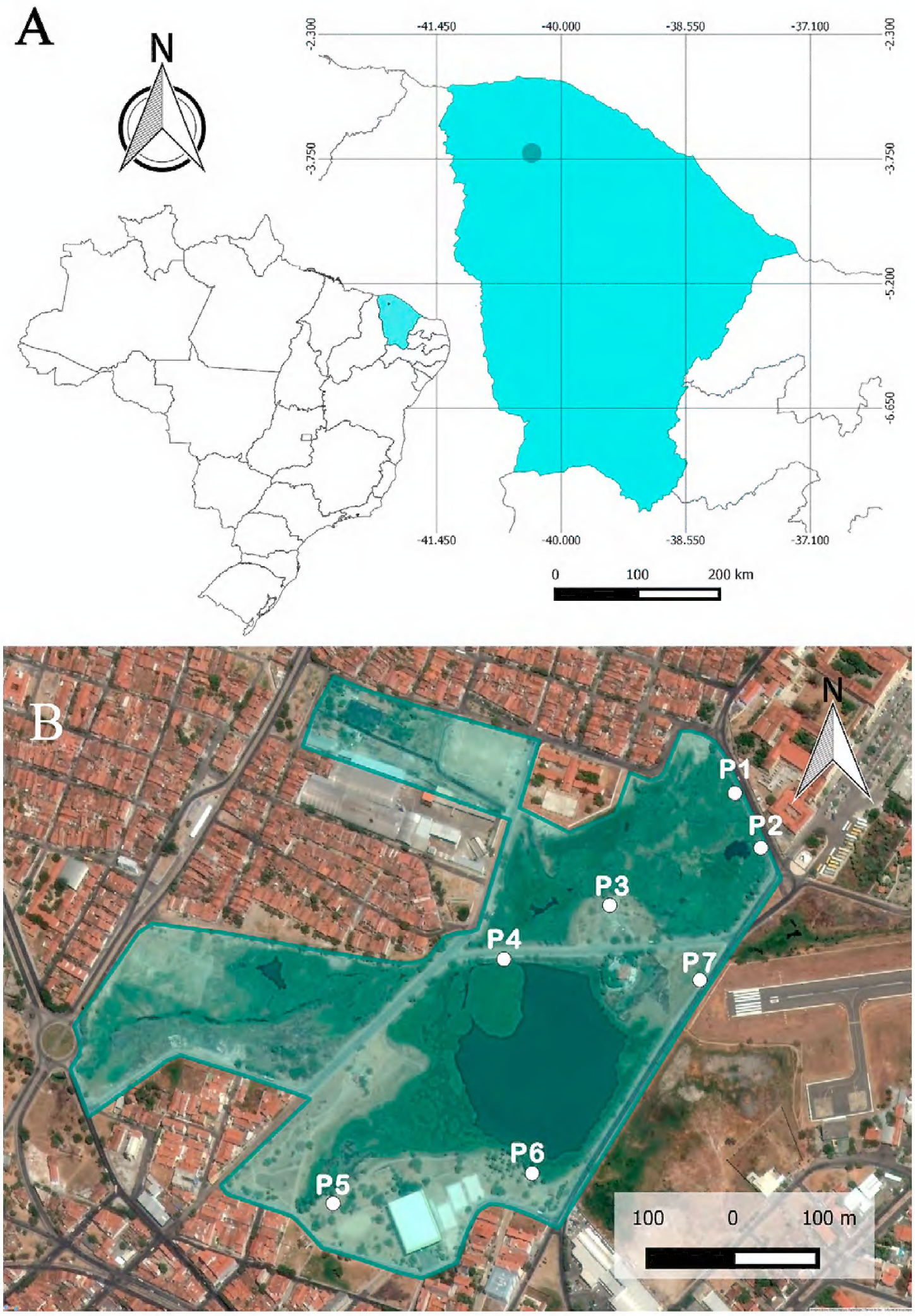

Figure 1. Location of Sobral (black dot) in Ceará state, northeastern Brazil (A) and satellite image showing the seven sampling points in the Parque Ecológico Lagoa da Fazenda (B). B was adapted from Google Earth™.

arbustiva'; Olmos et al. 2005). Notably, avifaunas from anthropic areas have been poorly studied in Ceará state to date, which limits the understanding on how urbanization influences the regional bird diversity.

In this context, we provide an inventory of the avifauna of Parque Ecológico Lagoa da Fazenda, a suburban park adjacent to Sobral city, and estimate the species richness. In addition, we report evidences of breeding, and identify the endemic Caatinga species occurring in the park. Finally, we discuss the potential effects of urbanization on the local avifauna and suggest management strategies to maintain, or even increase, the local bird diversity.

MATERIAL AND METHODS

Study area

Data were collected at Parque Ecológico Lagoa da Fazenda (PELF; 03°40′52″ S, 40°20′39″ W; 70 m above sea level), in the municipality of Sobral, Ceará state (Figure 1). This park was implemented in 1991 (decree 21.303) and covers around of 19 ha (Ceará 1991). Regional climate presents mean annual temperature around 28°C and annual precipitation lower than 750 mm, which is restricted to few months per year. The vegetation of the region is composed by open and bushy caatingas ('*Caatinga Arbustiva Aberta*'), forest with

Carnauba Wax Palm ('*Floresta Mista Dicotilo-Palmácea*), deciduous forest with spiny species ('*Floresta Caducifólia Espinhosa*') and, at higher altitudes, tropical semideciduous forest ('*Floresta Subcaducifólia Tropical Pluvial*') (IPECE 2013; Nimer 1972). The hydrographic system encompasses three rivers (Acaraú, Aracatiaçu and Jaibaras) that, along with '*Serra da Meruoca*' range, influence the local climate (Lima & Assis 2005).

PELF encompasses a central lake surrounded by emergent or floating macrophytic vegetation. Drier terrains are covered by sparse, mostly exotic trees and treelets species, such as *Pithecellobium dulce* (Roxb.) Benth., but native species are also present such as *Copernicia prunifera* (Miller) H. E. Moore) and *Mimosa tenuiflora* (Willd.) Poir. Historically, the PELF has been widely used for recreational purposes but these activities have decreased due to sewage disposal into the lake (Aguiar Júnior 2005).

Data collection and analysis

Data collection was from May 2014 to April 2015 within seven circular plots each with a radius of 35 m and placed at least 70 m apart (Figure 2). Each plot was sampled twice a month for 15 minutes, starting around 6:30 h, and totaling 42 h of observations. During each 15-minute sampling period, all bird species were identified and the number of individuals was counted. Binocular and photographic cameras (30 × zoom) were used to record birds and specialized field guides were used for species identification (Gwynne et al. 2003; Corbo et al. 2013; Sigrist 2013). Species were documented by voucher photos or voice recordings which were deposited at Wikiaves (http://www.wikiaves.com.br), an open-access on-line repository. Species names follow the Brazilian Ornithological Records Committee (CBRO 2014).

Point counts were distributed in order to cover all the representative environments within the PELF (Figures 1 and 2): Point 1 is covered mostly by tall aquatic grasses which are occasionally removed to feed cattle; Point 2 borders a little lake surrounded by tall aquatic grasses; Point 3 covers the interface between a flooded area covered by grasses and a drier terrain with scattered trees; Point 4 borders the main lake which is often covered by dense patches of the floating macrophyte *Eichhornia crassipes* (Mart.) Solms, which changes its location within the lake according to the wind direction. The water level is seasonally variable in both lakes (Points 2 and 4) but neither lake was observed totally dry; Point 5 is a drier terrain covered by scarce short grasses and planted exotic trees such as *P. dulce*, *Azadirachta indica* A. Juss., and *Libidibia ferrea* (Mart. ExTul.) L.P.Queiroz; Point 6 presents a patch of *Cocos nucifera* L. which were planted along the shore of the larger lake where *E. crassipes* and *Ludwigia octovalvis* (Jacq.) P.H.Raven treelets occur; Point 7 is seasonally flooded and presents scattered individuals of *Mimosa tenuiflora*, *C. prunifera*, and *P. dulce*.

Species richness was estimated by Chao 1 and Jackknife 1 (Magurran 2004) using the EstimateS 9.1.0 software

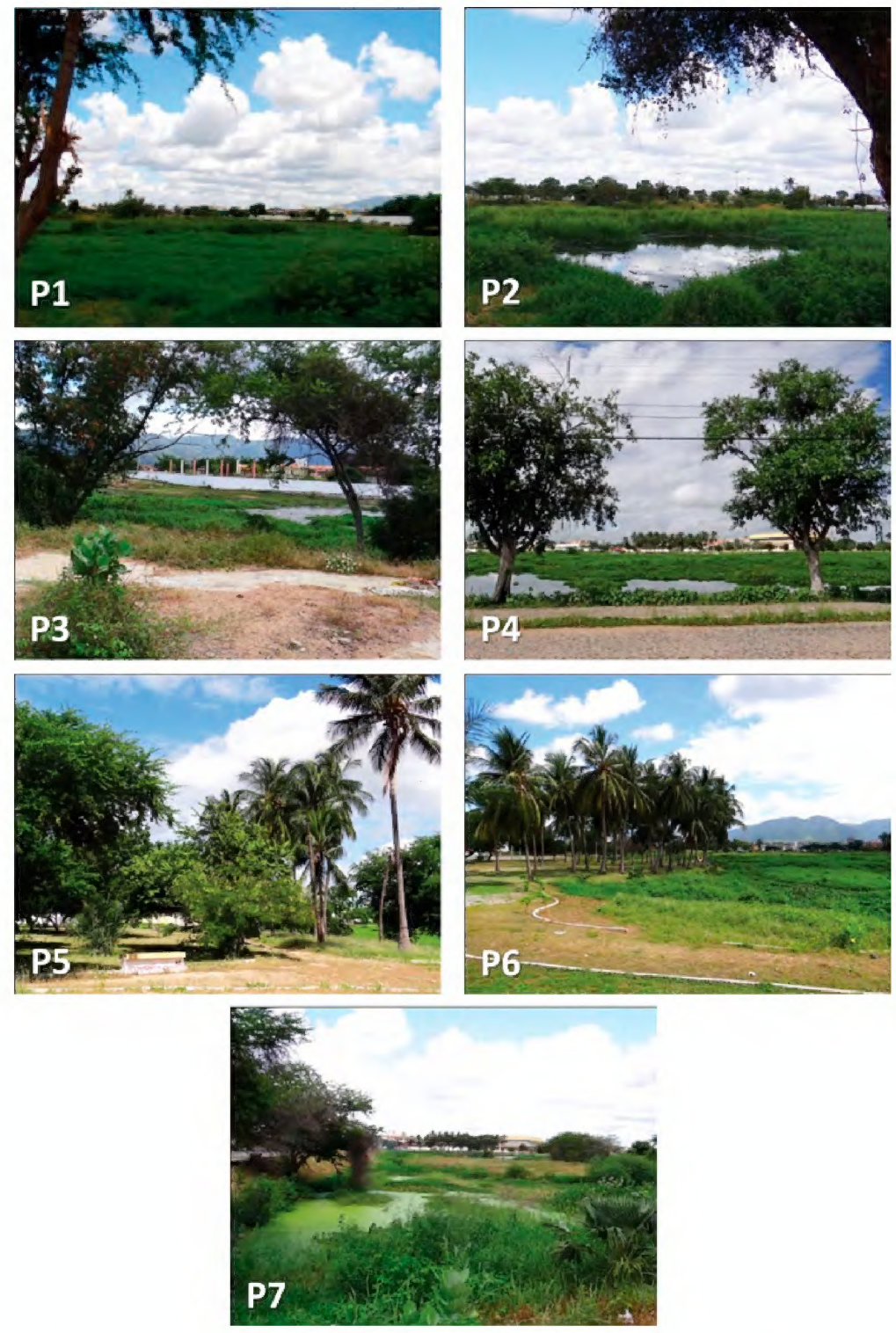

Figure 2. Environmental features and vegetation at each of the seven sampling points in Parque Ecológico Lagoa da Fazenda. Photos by A. C. Brasileiro. See Figure 1 for location within the park.

(Colwell 2011). We defined sampling as the list of species and their abundances at all seven points summed per sampling day, so that a month had two samples. Species recorded outside the sampling intervals were added to the inventory, but were not considered for the richness estimation. To check sampling sufficiency, we plotted accumulated species richness and mean estimated richness by both metrics along the gradient of sampling accumulation (Figure 3).

Evidences of breeding were collected from January 2014 to April 2015. As evidence, we considered active nests (or those under construction), nestlings, or fledglings (i.e., individuals with low dispersal ability), and/or adults carrying feeding items. Endangered species were classified according Birdlife International (2015) and Caatinga endemics, according Olmos et al. (2005).

RESULTS

We recorded 82 species at the Parque Ecológico Lagoa da Fazenda, of which 69 (84.0% of the total) species were documented by photographs or voice recordings (Table 1). *Dendrocygna viduata*, *Nomonyx dominica*, *Tyto furcata*,

Aramides cajaneus, and *Sturnella superciliaris* were only observed outside the sampling period. The most species-rich families were Tyrannidae (10 species) and Thraupidae, Ardeidae and Rallidae (seven species each). Species richness at PELF was estimated between 88.14 ± 8.23 (Chao1) and 94.25 ± 3.97 species (Jackknife 1). None of the species is currently classified as globally endangered. Three species are endemic to the Caatinga: *Pseudoseisura cristata*, *Agelaioides fringillarius,* and *Paroaria dominicana*. Three species are introduced: *Passer domesticus*, *Estrilda astrild,* and *Columba livia.*

Evidence for breeding was found for 16 species (19.5% of the total; Table 2). Curiously, *Certhiaxis cinnamomeus* and *Pseudoseisura cristata* used plastic materials to build their nests (Figure 4A, B). Remarkably, a nest of *Porzana flaviventer* was found in January 2014 containing five cream-colored eggs (Figure 4C, D).

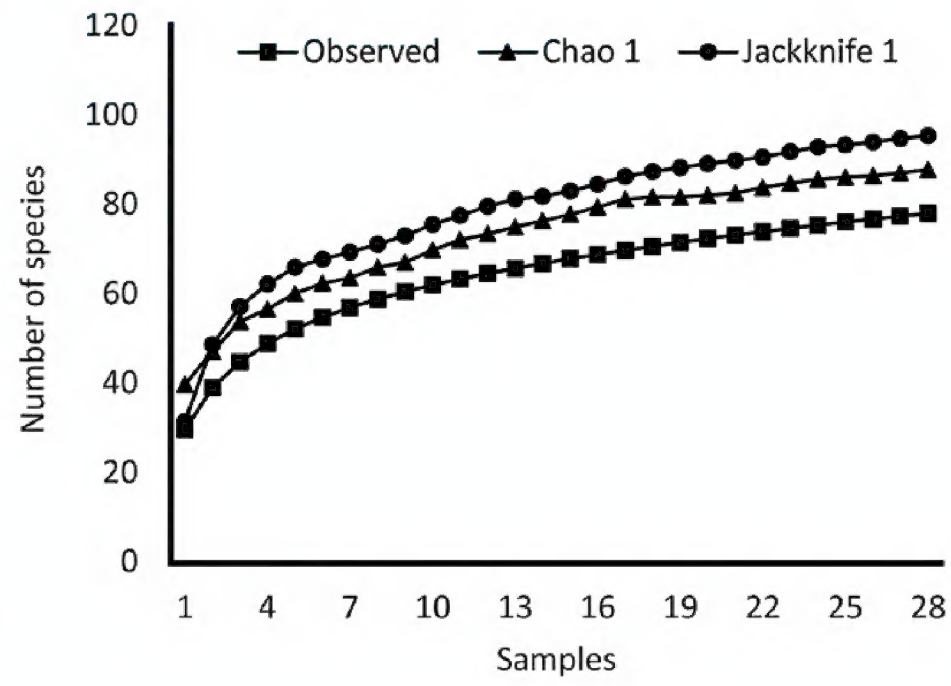

Figure 3. Observed species accumulation curve (square) and estimated by Chao 1 (triangles) and Jackknife 1 (dots) for 28 samples.

Below, we list characteristics used to identify species that are either rare to Ceará or potentially confused with similar species:

- *Porzana flaviventer*: black bill; brown iris; pale yellow legs; yellowish throat and breast; body sides black and white stripes; black crown; marked upper ocular.
- *Pardirallus maculatus*: long yellow-greenish bill with a red spot in the basis; reddish legs; red iris; black and white spots or stripes in the neck, breast and belly; black and brownish spots in the back with greenish bright.
- *Laterallus melanophaius*: dark bill with greenish in the inner basis; dark olive legs; brownish upperparts; ferruginous face and neck-sides; white throat, breast and abdomen; back and white barring on the flanks.
- *Laterallus exilis*: black bill with greenish in the inner basis; light grey face sides, neck and breast; white-barrred belly; notable ferrugineus nape and upper neck.
- *Ixobrychus exilis*: straight long yellow bill; blackish cape (male); pale tawny-chestnut face and neck-sides; white throat; light brownish neck with white vertical stripes; light brownish underparts and legs; black back.
- *Botaurus pinnatus*: straight long yellowish bill; white throat; pale yellow and black barred head and neck, turning into thicker irregular bars on the wings and back.
- *Polytmus guainumbi*: long black bill, slightly decurved (reddish upper mandible in males); golden brighten green body; white upper ocular stripe; black ocular stripe; whitish belly.
- *Nomonyx dominica:* male: blue bill with black tip; black face; white periocular ring; dark brown body with black spots; female: plumbeous bill; greyish body with irregular small black dots in the breast; two black stripes in the face with light brown background.
- *Ardea alba:* long straight yellow bill; yellow iris; black legs and feet; entirely white body; bigger than any other white heron.
- *Aramides cajaneus*: yellow bill with a greenish tip; red iris; yellow legs; entirely grey head and neck; rufous breast and belly; brown back and short darker tail.
- *Tringa solitaria*: long straight yellow bills with black tip;

Table 1. Bird species recorded in Parque Ecológico Lagoa da Fazenda, Ceará state, northeastern Brazil. Asterisk indicates species recorded only outside of the sampling periods. Species with several records within the park were demarcated with a general geographical coordinate (03°40′52.98″ S, 040°20′39.51″ W).

Order/family/species	Photo or voice vouchers	Latitude	Longitude
Anseriformes Linnaeus, 1758			
Anatidae Leach, 1820			
**Dendrocygna viduata* (Linnaeus, 1766)	wikiaves.com/1663415	03°40′52.98″ S	040°20′39.51″ W
**Nomonyx dominica* (Linnaeus, 1766)		03°40′52.98″ S	040°20′39.51″ W
Podicipediformes Fürbringer, 1888			
Podicipedidae Bonaparte, 1831			
Tachybaptus dominicus (Linnaeus, 1766)	wikiaves.com/1668651	03°40′52.98″ S	040°20′39.51″ W
Podilymbus podiceps (Linnaeus, 1758)	wikiaves.com/1219037	03°40′52.98″ S	040°20′39.51″ W
Pelecaniformes Sharpe, 1891			
Ardeidae Leach, 1820			
Tigrisoma lineatum (Boddaert, 1783)	wikiaves.com/1666016	03°40′52.98″ S	040°20′39.51″ W
Botaurus pinnatus (Wagler, 1829)	wikiaves.com/1663414	03°40′52.98″ S	040°20′39.51″ W
Ixobrychus exilis (Gmelin, 1789)	wikiaves.com/1304464	03°40′52.98″ S	040°20′39.51″ W
Butorides striata (Linnaeus, 1758)	wikiaves.com/1689417	03°40′52.98″ S	040°20′39.51″ W

Continued

Table 1. *Continued.*

Order/family/species	Photo or voice vouchers	Latitude	Longitude
Bubulcus ibis (Linnaeus, 1758)	wikiaves.com/1662738	03°40′52.98″ S	040°20′39.51″ W
Ardea alba Linnaeus, 1758		03°40′52.98″ S	040°20′39.51″ W
Egretta thula (Molina, 1782)	wikiaves.com/1666015	03°40′52.98″ S	040°20′39.51″ W
Cathartiformes Seebohm, 1890			
Cathartidae Lafresnaye, 1839			
Coragyps atratus (Bechstein, 1793)	wikiaves.com/1689356	03°40′38.66″ S	040°20′31.74″ W
Cathartes aura (Linnaeus, 1758)	wikiaves.com/1677964	03°40′38.96″ S	040°20′30.95″ W
Cathartes burrovianus Cassin, 1845	wikiaves.com/1662724	03°40′52.98″ S	040°20′39.51″ W
Accipitriformes Bonaparte, 1831			
Accipitridae Vigors, 1824			
Geranospiza caerulescens (Vieillot, 1817)	wikiaves.com/1663487	03°40′41.78″ S	040°20′30.34″ W
Rupornis magnirostris (Gmelin, 1788)		03°40′52.98″ S	040°20′39.51″ W
Gruiformes Bonaparte, 1854			
Aramidae Bonaparte, 1852			
Aramus guarauna (Linnaeus, 1766)		03°40′51.31″ S	040°20′37.64″ W
Rallidae Rafinesque, 1815			
**Aramides cajaneus* (Statius Muller, 1776)		03°40′52.98″ S	040°20′39.51″ W
Laterallus melanophaius (Vieillot, 1819)	wikiaves.com/1636037	03°40′52.98″ S	040°20′39.51″ W
Laterallus exilis (Temminck, 1831)	wikiaves.com/1677983	03°40′52.98″ S	040°20′39.51″ W
Porzana flaviventer (Boddaert, 1783)	wikiaves.com/1696003	03°40′52.98″ S	040°20′39.51″ W
Pardirallus maculatus (Boddaert, 1783)	wikiaves.com/1175917	03°40′45.23″ S	040°20′40.70″ W
Gallinula galeata (Lichtenstein, 1818)	wikiaves.com/1450751	03°40′52.98″ S	040°20′39.51″ W
Porphyrio martinicus (Linnaeus, 1766)	wikiaves.com/1662726	03°40′52.98″ S	040°20′39.51″ W
Charadriiformes Huxley, 1867			
Charadriidae Leach, 1820			
Vanellus chilensis (Molina, 1782)	wikiaves.com/1175925	03°40′52.98″ S	040°20′39.51″ W
Scolopacidae Rafinesque, 1815			
Tringa solitaria Wilson, 1813		03°40′42.24″ S	040°20′36.88″ W
Tringa flavipes (Gmelin, 1789)	wikiaves.com/1666022	03°40′52.98″ S	040°20′39.51″ W
Jacanidae Chenu & Des Murs, 1854			
Jacana jacana (Linnaeus, 1766)	wikiaves.com/1663417	03°40′52.98″ S	040°20′39.51″ W
Columbiformes Latham, 1790			
Columbidae Leach, 1820			
Columbina talpacoti (Temminck, 1811)	wikiaves.com/1663486	03°40′52.98″ S	040°20′39.51″ W
Columbina picui (Temminck, 1813)	wikiaves.com/1677985	03°40′52.98″ S	040°20′39.51″ W
Columba livia Gmelin, 1789	wikiaves.com/1677972	03°40′52.98″ S	040°20′39.51″ W
Cuculiformes Wagler, 1830			
Cuculidae Leach, 1820			
Coccyzus sp.		03°40′53.84″ S	040°20′45.93″ W
Crotophaga ani Linnaeus, 1758	wikiaves.com/1662722	03°40′52.98″ S	040°20′39.51″ W
Guira guira (Gmelin, 1788)		03°40′52.98″ S	040°20′39.51″ W
Strigiformes Wagler, 1830			
Tytonidae Mathews, 1912			
**Tyto furcata* (Temminck, 1827)		03°40′52.98″ S	040°20′39.51″ W
Caprimulgiformes Ridgway, 1881			
Caprimulgidae Vigors, 1825			
Hydropsalis parvula (Gould, 1837)	wikiaves.com/1634479	03°40′52.98″ S	040°20′39.51″ W
Apodiformes Peters, 1940			
Apodidae Olphe-Galliard, 1887			
Tachornis squamata (Cassin, 1853)	wikiaves.com/1666014	03°40′52.98″ S	040°20′39.51″ W
Trochilidae Vigors, 1825			
Eupetomena macroura (Gmelin, 1788)	wikiaves.com/1666041	03°40′52.98″ S	040°20′39.51″ W
Chlorostilbon lucidus (Shaw, 1812)		03°40′52.98″ S	040°20′39.51″ W
Polytmus guainumbi (Pallas, 1764)	wikiaves.com/1666023	03°40′53.95″ S	040°20′45.82″ W
Amazilia fimbriata (Gmelin, 1788)	wikiaves.com/1666017	03°40′44.44″S	040°20′38.37″ W
Coraciiformes Forbes, 1844			
Alcedinidae Rafinesque, 1815			
Chloroceryle amazona (Latham, 1790)	wikiaves.com/1696010	03°40′40.89″ S	40°20′30.15″ W
Piciformes Meyer & Wolf, 1810			
Picidae Leach, 1820			
Melanerpes candidus (Otto, 1796)	wikiaves.com/1662736	03°40′52.79″ S	040°20′38.20″ W

Continued

Table 1. *Continued.*

Order/family/species	Photo or voice vouchers	Latitude	Longitude
Falconiformes Bonaparte, 1831			
Falconidae Leach, 1820			
Caracara plancus (Miller, 1777)	wikiaves.com/1689391	03°40′52.98″ S	040°20′39.51″ W
Falco femoralis Temminck, 1822		03°40′52.98″ S	040°20′39.51″ W
Psittaciformes Wagler, 1830			
Psittacidae Rafinesque, 1815			
Forpus xanthopterygius (Spix, 1824)	wikiaves.com/1662725	03°40′52.98″ S	040°20′39.51″ W
Passeriformes Linnaeus, 1758			
Furnariidae Gray, 1840			
Furnarius figulus (Lichtenstein, 1823)	wikiaves.com/1689357	03°40′52.98″ S	040°20′39.51″ W
Pseudoseisura cristata (Spix, 1824)	wikiaves.com/1670934	03°40′52.98″ S	040°20′39.51″ W
Certhiaxis cinnamomeus (Gmelin, 1788)	wikiaves.com/1662737	03°40′52.98″ S	040°20′39.51″ W
Tityridae Gray, 1840			
Xenopsaris albinucha (Burmeister, 1869)	wikiaves.com/1636101	03°40′54.12″ S	040°20′45.22″ W
Rhynchocyclidae Berlepsch, 1907			
Tolmomyias flaviventris (Wied, 1831)	wikiaves.com/1696011	03°40′52.98″ S	040°20′39.51″ W
Todirostrum cinereum (Linnaeus, 1766)	wikiaves.com/1663485	03°40′52.98″ S	040°20′39.51″ W
Tyrannidae Vigors, 1825			
Machetornis rixosa (Vieillot, 1819)	wikiaves.com/1666037	03°40′52.98″ S	040°20′39.51″ W
Phaeomyias murina (Spix, 1825)	wikiaves.com/1450750	03°40′52.98″ S	040°20′39.51″ W
Pitangus sulphuratus (Linnaeus, 1766)	wikiaves.com/1677965	03°40′52.98″ S	040°20′39.51″ W
Myiozetetes similis (Spix, 1825)	wikiaves.com/1666036	03°40′52.98″ S	040°20′39.51″ W
Tyrannus melancholicus Vieillot, 1819	wikiaves.com/1696012	03°40′52.98″ S	040°20′39.51″ W
Tyrannus savanna Vieillot, 1808	wikiaves.com/1689392	03°40′54.38″ S	040°20′45.22″ W
Empidonomus varius (Vieillot, 1818)		03°40′54.32″ S	040°20′45.88″ W
Fluvicola albiventer (Spix, 1825)	wikiaves.com/1696009	03°40′52.98″ S	040°20′39.51″ W
Fluvicola nengeta (Linnaeus, 1766)	wikiaves.com/1662723	03°40′52.98″ S	040°20′39.51″ W
Arundinicola leucocephala (Linnaeus, 1764)	wikiaves.com/1662735	03°40′52.98″ S	040°20′39.51″ W
Hirundinidae Rafinesque, 1815			
Progne chalybea (Gmelin, 1789)	wikiaves.com/1689408	03°40′52.98″ S	040°20′39.51″ W
Tachycineta albiventer (Boddaert, 1783)	wikiaves.com/1663416	03°40′52.98″ S	040°20′39.51″ W
Troglodytidae Swainson, 1831			
Troglodytes musculus Naumann, 1823	wikiaves.com/1696004	03°40′52.98″ S	040°20′39.51″ W
Polioptilidae Baird, 1858			
Polioptila plumbea (Gmelin, 1788)	wikiaves.com/1661592	03°40′42.21″ S	040°20′35.34″ W
Turdidae Rafinesque, 1815			
Turdus rufiventris Vieillot, 1818	wikiaves.com/1689398	03°40′52.98″ S	040°20′39.51″ W
Mimidae Bonaparte, 1853			
Mimus saturninus (Lichtenstein, 1823)	wikiaves.com/1689397	03°40′52.98″ S	040°20′39.51″ W
Parulidae Wetmore Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer, 1947			
Myiothlypis flaveola Baird, 1865	wikiaves.com/1634480	03°40′53.36″ S	040°20′44.68″ W
Icteridae Vigors, 1825			
Chrysomus ruficapillus (Vieillot, 1819)	wikiaves.com/1677989	03°40′52.98″ S	040°20′39.51″ W
Agelaioides fringillarius (Spix, 1824)	wikiaves.com/1661595	03°40′52.98″ S	040°20′39.51″ W
Molothrus bonariensis (Gmelin, 1789)	wikiaves.com/1677976	03°40′52.98″ S	040°20′39.51″ W
**Sturnella superciliaris* (Bonaparte, 1850)		03°40′44.93″ S	040°20′40.20″ W
Thraupidae Cabanis, 1847			
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	wikiaves.com/1414514	03°40′52.98″ S	040°20′39.51″ W
Tangara sayaca (Linnaeus, 1766)	wikiaves.com/1670955	03°40′52.98″ S	040°20′39.51″ W
Tangara palmarum (Wied, 1823)	wikiaves.com/1670933	03°40′52.98″ S	040°20′39.51″ W
Tangara cayana (Linnaeus, 1766)	wikiaves.com/1668652	03°40′52.98″ S	040°20′39.51″ W
Paroaria dominicana (Linnaeus, 1758)	wikiaves.com/1668675	03°40′52.98″ S	040°20′39.51″ W
Sicalis flaveola (Linnaeus, 1766)	wikiaves.com/1689358	03°40′52.98″ S	040°20′39.51″ W
Volatinia jacarina (Linnaeus, 1766)	wikiaves.com/1677977	03°40′52.98″ S	040°20′39.51″ W
Estrildidae Bonaparte, 1850			
Estrilda astrild (Linnaeus, 1758)	wikiaves.com/1661593	03°40′52.98″ S	040°20′39.51″ W
Passeridae Rafinesque, 1815			
Passer domesticus (Linnaeus, 1758)	wikiaves.com/1670958	03°40′52.98″ S	040°20′39.51″ W

Figure 4. Breeding evidence in Parque Ecológico Lagoa da Fazenda, Sobral, Ceará state, northeastern Brazil. Nest of *Certhiaxis cinnamomeus* (**A**) and *Pseudoseisura cristata* (**B**), nest and eggs of *Porzana flaviventer* (**C**), and an adult incubating eggs (**D**). Nests A and B utilized blue plastic stick and pieces of plastic bags, respectively. Photos by A.C. Brasileiro (A and B) and J.A. Neto (C and D).

Table 2. Bird species breeding at Parque Ecológico Lagoa da Fazenda, Ceará state, northeastern Brazil.

Family/Species	Type of breeding evidence	Month(s)	NBE*
Podicipedidae			
Tachybaptus dominicus	Fledglings	May	1
Ardeidae			
Butorides striata	Nest under construction	Feb	1
Rallidae			
Porzana flaviventer	Active nest	Jan	1
Gallinula galeata	Fledglings	Feb–Apr, Jun	6
Porphyrio martinicus	Fledglings	Mar, Jul	2
Charadriidae			
Vanellus chilensis	Active nest	Apr	1
Jacanidae			
Jacana jacana	Fledglings	Jan–Apr	4
Columbidae			
Columbina talpacoti	Nest under construction	Apr	1
Columbina picui	Active nest	Sep	1
Furnariidae			
Furnarius figulus	Nest under construction	Sep	2
Pseudoseisura cristata	Nest under construction	Jan	1
	Adults carrying food items	Mar	1
Certhiaxis cinnamomeus	Nest under construction	Mar–Apr, Jun	
	Adults carrying food items	Dec–Jan	2
Rhynchocyclidae			
Todirostrum cinereum	Nest under construction	Mar	1
Tyrannidae			
Fluvicola albiventer	Nest under construction	Mar	2
Arundinicola leucocephala	Nest under construction	Mar	1
Troglodytidae			
Troglodytes musculus	Adults carrying food items	Mar	1

* Number of independent observations of breeding evidence

yellowish legs; white ocular ring; grey upperparts with pale spots; head and breast finely streaked dark brown; white breast and belly.

DISCUSSION

Our findings reveal that PELF harbors moderate species richness. Even though some additional species are expected, both richness estimators indicate that our sampling was sufficient to detect most species occurring in the area (Figure 3). The assemblage encompasses mostly aquatic birds, such as those belonging to families Rallidae, Ardeidae, and Scolopacidae. Several species breed in the area and endemic species are also present, but endangered species were absent.

Species richness at PELF can be considered intermediate to other bird inventories from northeastern Brazil, which reported about 130 species for other areas of Caatinga *strictu sensu* (Nascimento 2000; Roos et al. 2006; Farias 2007, 2009; Farias et al. 2010; Pereira & Azevedo Júnior 2011). However, direct comparisons among studies should be carefully considered due to environmental and sampling differences, such as the size of the sampled area, time span, methods and effort (Vizentin-Bugoni et al. 2015). When similar but non-urbanized areas such as other wetlands in Caatinga region are considered, similar richness are reported: 90 species for three vernal pools in Rio Grande do Norte state (Pereira 2010) and 125 species in vernal pools and surroundings in Pernambuco

state (*'Lagoas de Petrolina'*; Olmos et al. 2005). Moreover, PELF presents species richness similar to other areas more strongly influenced by urbanization, such as a patch of Atlantic Forest in the city of Aracaju (72 species; Moreira & Machado 2014) and the Botanical Garden in the city of Recife (90 species; Pereira et al. 2011), which suggests that the PELF avifauna is likely reduced due to the effects of the urbanization process.

Several species reported for PELF are known from few previous records in Ceará, such as *Pardirallus maculatus*, *Laterallus melanophaius*, *L. exilis*, *Ixobrychus exilis, Botaurus pinnatus,* and *Polytmus guainumbi* (Nascimento 2000; Pacheco 2004; Girão et al. 2007; Albano & Girão 2008; Girão et al. 2009; Girão et al. 2013). *Porzana flaviventer* had not yet been documented in inventory birds for Ceará state, so the record extends its distribution in northeastern Brazil (Lamm, 1948; Souza 2008; Pereira et al. 2014).

The effects of anthropogenic disturbances are apparent in several features of the PELF bird assemblage. For example, the lack of globally endangered species at PELF is likely a consequence of local extinction, which could be indicative of the increasing urban expansion, sewage dumping, and vegetation removal on the avifauna of the park. Anthropic influences may also explain the presence of three exotic species which are typically associated with urban areas. Interestingly, the ability of some species to tolerate anthropic disturbances reflects also in their behavior; for instance, *Certhiaxis cinnamomeus* and *Pseudoseisura cristata* incorporated artificial material on their nest structures (Figure 4A, B, respectively).

Despite of the depauperate bird assemblage, the PELF harbors several aquatic and endemic species, and also includes *Sicalis flaveola* and *Paroaria dominicana* (endemic), which are widely caught for the illegal cage-bird market in northeastern Brazil (Fernandes-Ferreira et al. 2012; Pereira & Brito 2005). Additionally, the PELF harbors long-distance migrant species, such as *Tringa solitaria* and *Tringa flavipes*, which are dependent on wetlands for stopovers along their migratory routes (Silva et al. 2003). The park is also a breeding site for *Porzana flaviventer*, a widely distributed but rare species, with a poorly understood life history (Taylor & De Juana 2013; Souza 2008). Its eggs were found in a nest on flooded ground, built with the leaves of surrounding vegetation (Figure 4C, D) and similar to an earlier description (Vilella et al. 2011). Altogether, we suggest that the PELF is regionally important for these birds.

Our findings are relevant to planning management strategies to maintain the local bird diversity. Among the measures that could maintain or even increase the bird species richness at PELF, the most urgent is the cessation of filling of the natural areas and the dumping of sewage in the lakes. Because waste water is usually nutrient-rich, it promotes eutrophication, leading to wetland loss and, therefore, affecting drastically the associated biodiversity (Keddy 2000). To increase species richness, we recommend the planting of native vegetation, such as ornithocoric or ornithophilous species, which provide food resources for birds, i.e. fruits and nectar, respectively. Some recommended species are *Ziziphus joazeiro* Mart., *Commiphora leptophloeos* (Mart.) J. B. Gillett, *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. ex S. Moore, and *Erythrina velutina* Willd. that in Portuguese are named *joazeiro*, *imburana*, *ipê-amarelo* and *mulungu*, respectively. In addition, the removal of the exotic *Azadirachta indica* should be considered, as this species is invasive and outcompetes the native flora (Moro et al. 2013, 2014) and indirectly may affect the avifauna.

In summary, we found that the Parque Ecológico Lagoa da Fazenda harbours considerable avifauna encompassing endemic, long-distance migratory, and several aquatic species. Despite the anthropogenic disturbances, which arguably have affected composition of the avifauna, the park is still used as breeding site for several species. Finally, we hope that our recommendations can guide further management plans aimed at maintaining or even increasing the avifauna of this park, which should contribute to bird conservation locally.

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